TONALITES AND GOLD MINERALIZATION IN AN ARCTIC ARCHEAN GREENSTONE BELT, HOPE BAY, NWT.

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1) Introduction

The Archean Hope Bay Greenstone Belt (HBGB) is part of the Bathurst block in the Slave Province, N.W.T. (figure 1 and 2). It is the subject of a 1:50000 mapping project undertaken by the CANADA-NWT Mineral Development Agreement. It is particulary favorable for gold ore deposits because of its low metamorphic grade and the abundance of mafic volcanics. This environment usualy presents a high potential for mineralization (Boyle, 1979; Colvine, et al, 1988). With an estimated cooling age of 2.677 +2/-1 Ga (Gebert, 1990, personnal communication) the belt is also comtemporaneous to most of the phases of auriferous mineralization, such as in the Abitibi Greenstone belt, or some australian greenstone belts and the Witwatersrand belt of South Africa.

The mapping project, led by James Gebert, has shown that the belt contains many potential showings of either silver or gold in its interior or on its periphery (Gebert, 1989). During the summer of '89, the author spent two weeks mapping the Ida Point gold showing, on a project supported by the MDA. It is located at the northernmost end of the HBGB. It represents an a-typical contact gold showing between the greenstone belt and the surrounding granitic terrain (figure 3).

The first objectives of this thesis study is to focus on the relationships between the intrusives and their peripheral mineralization. The important factors to determine are: 1) the petrology of the host rocks and the intrusives, 2) the nature of the prevailing structures, 3) the relationships between the mafic volcanics and granitic rocks and 4) the origin of the mineralization. This information could later provide some prospecting guides in the HBGB.

Previous work on Ida Point includes the prospection and trenching of Duncan Derry for the Hope Bay Syndicate in 1967. Twenty years later, Abermine Corporation spent two years on a gold exploration program in the northern part of the HBGB including Ida Point. Both attempts failed to find a significant deposit. However, they established very local and non-extensive showings containing between .5 to 7 oz/ton Au. In 1967 this was below the

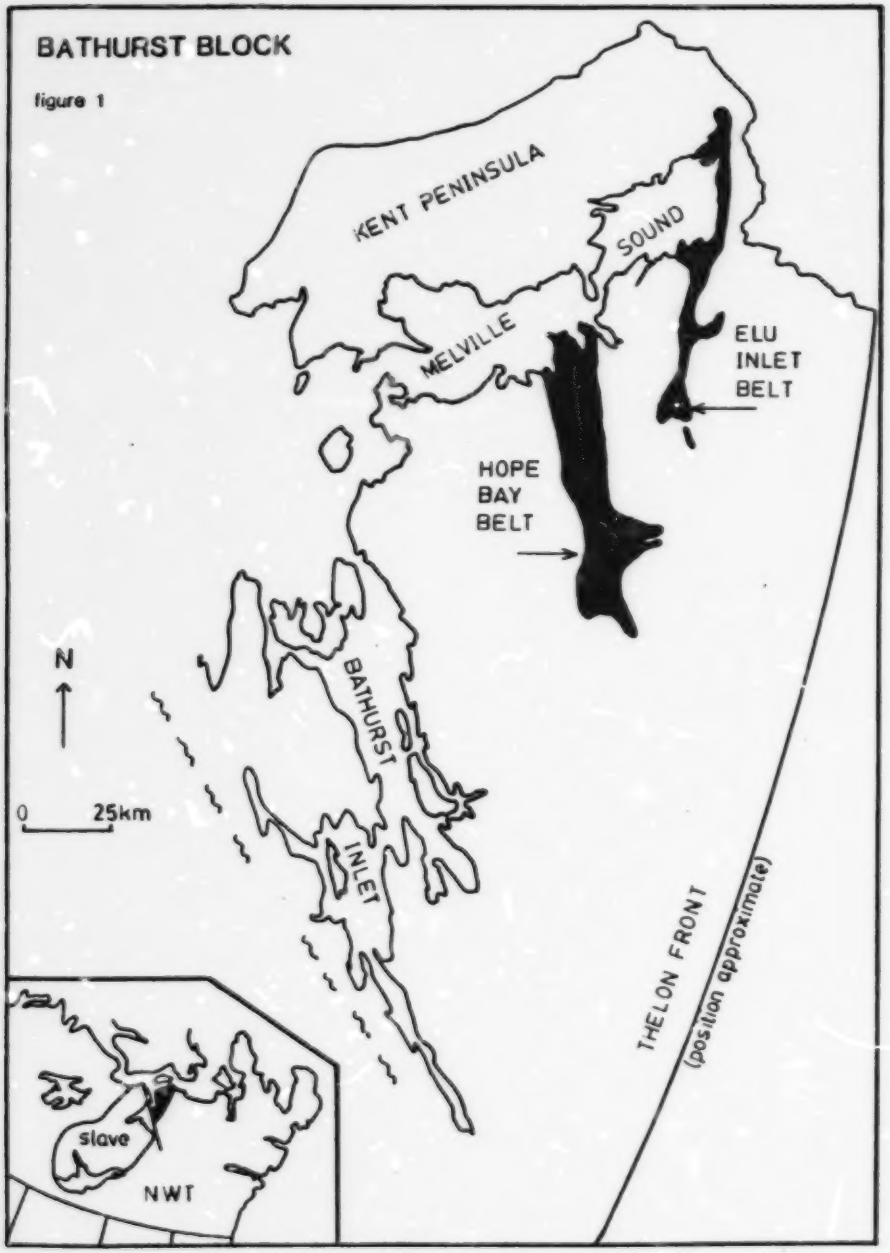


Figure 1: Bathurst bloc, Slave Province N.W.T.

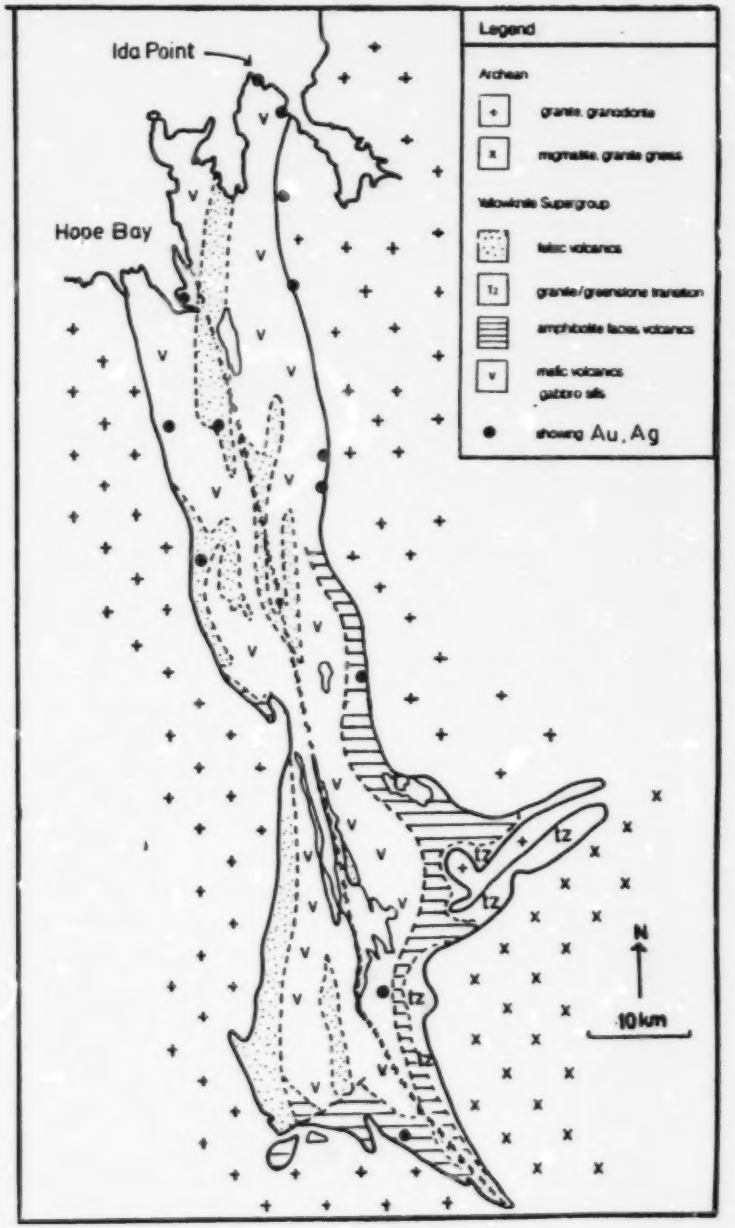


Figure 2: The geology of Hope Bay, N.W.T.

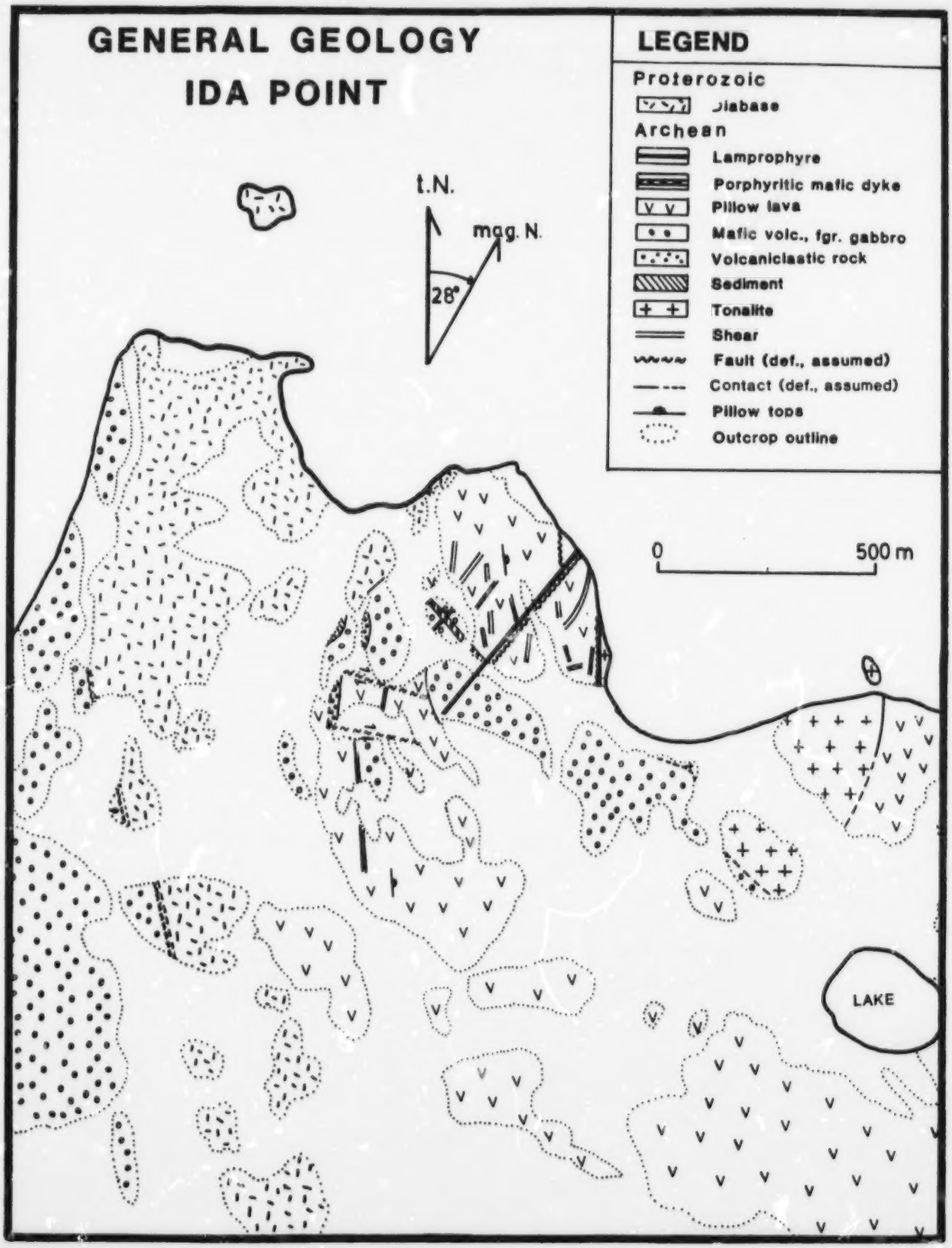

GENERAL GEOLOGY
IDA POINT
LEGEND
Proterozoic
Diabase
Archean
Lamprophyre
Porphyritic mafic dyke
Pillow lava
Mafic volc., fgr. gabbro
Volcaniclastic rock
Sediment
Tonalite
Shear
Fault (def., assumed)
Contact (def., assumed)
Pillow tops
Outcrop outline
t.N.
mag. N.
28°
0
500 m
LAKE

figure 3

cut-off grade. In 1987, preliminary results were encouraging but Abermine was unable to continue the project due to financial problems.

2) Lithology

2.1 Regional geology

The volcanic rocks in the HBGB consist of essentially mafic to intermediate rocks, in pillowed and massive flows. The common felsic volcanic rocks include tuffs, lapilli tuffs, volcaniclastics and conglomerates with volcanic clasts. Primary felsic volcanics are uncommon. Sedimentary rocks occur mostly as thin interflow turbidites.

Gabbroic rocks intrude the supracrustal rocks of the belt. Ultramafic sills occur along the length of the belt although thicker sills are confined to the northern portion of the belt. Granite to granodiorite borders the belt to the northeast and the west. These rocks will be referred furtheron as the Eastern Contact Granitoids (ECG). The southeastern portion of the belt in bordered by a gneissic terrane. The belt is regionally metamorphosed to greenschist facies and increase to amphibolite towards the eastern margin. This margin is often a heterogeneous terrane where the granitic rock intrude the mafic volcanics (transition zone).

Pillow topping direction suggest the presence of a north-trending anticline underlying the central zone of the belt (figure 2). Intense carbonate alteration is associated with a shear zone close to, or coincident with this anticlinal fold axis. This axial zone is locally cut by thin auriferous quartz carbonate veins. To the east a series of auriferous quartz-carbonate veins cut the amphibolitic margin of the belt (Gebert, 1989).

2.2 Ida Point geology

The predominant lithology at Ida Point consist of pillow lavas and massive flows cut by a granitoid rock to the east. A late proterozoic diabase sill cuts the lavas to the west (figure 3). The younging direction is to the east as revealed by the pillow lavas.

Sediments

A thin sedimentary sequence lies on the western side of the map area. These rocks are probably located at the base of the volcanic pile. A garnet rich layer is present in the middle of the sediments outcrop. This zone can be considered as one of three elements: a metamorphosed sedimentary layer, a garnet rich vein or a combination of both. This third option is possible if metamorphism has taken place in a host rock that was already fractured. Thin section examination shows that garnets are zoned and crystallized simultaneously with coarse grained radial chloritoid from the vein walls to the center. Garnets may have been formed under heat conditions provided by the small intrusion on the east side of Ida point.

Volcaniclastic rocks with centimetre size fragments of altered material are located on top of the sediments.

MASSIVE SULFIDE ALTERATION ZONE ! ONAMAN RIVER AREA NEAR BEARDMORE NORTON UNIVERSITY OF MN OR J. FRANKLIN

Volcanic Rocks

Basalt, fine grained gabbro and pillow lavas follow in the stratigraphic sequence. Pillow lavas extrusive centers are commonly altered to chlorite. However, their selvages often consist of amphibole needles. Most of the pillows are deformed laterally and vertically. Varioles are uncommon on Ida Point. Nevertheless when they are present, they are flattened and reoriented in a north-south fashion.

Intrusive Rocks

A small intrusion, the Ida Point Intrusive (IPI), appears as a small isolated plug 500 m in diametre on the eastern edge of Ida Point (figure 3). Its dip angle, related by the crosscuting shear zone is very steep towards the west. It consists mostly of plagioclase and quartz with varying percentages of biotite and clinopyroxenes. Alteration minerals such as chlorite, sericite and epidote are invariably present. Apatite and calcite are also present in minor quantities (1-3 %). Opaque minerals essentially consist of magnetite pseudomorphs partially altered to hematite. The IPI can thus be classified as a magnetite series granitoid following Ishihara's (1981) classification. Contact metamorphism developed along the western side of the plug in an area where the intrusion is in ductile fault contact with the pillow lavas. The eastern edge of the pluton is marked by a brittle fault contact.

Metamorphism is not present on that side. Gold mineralization is located only the west side of the pluton.

The area is also cut by several generations of late dykes (figure 3). These include a porphyric gabbroic dyke with centimetre size chloritic phenocrysts. Minor felsic dykes crosscut the amphibolite margin. They are often mineralized with pyrite and chalcopyrite near the intrusion. Their association with the IPI is probable.

Lamprophyre

A lamprophyre dyke with biotite phenocrysts cuts most lithologies on Ida Point. However, its relationship with the IPI and the diabase sills is not exposed. The dyke is one to two metres in thickness and extends for 300 m in a northeast direction cuting the mineralized zone. A large brittle fault with 10 metres of sub horizontal displacement is parallel to the dyke. Within the fault, the lamprophyre is carbonated and phenocrysts are stretched and reoriented in the fault direction suggesting postmagmatic deformation. The stratigraphic sequence is summarized in table 1.

Table 1: description of the rock types of Ida Point.

Rock type	Age	Characteristics
Diabase	Proterozoic	300m thick, western side of Ida Point
Lamprophyre	Unknown, possibly archean	Cuts Au mineralization, associated with a dextral horizontal brittle fault oriented NE-SW.
Porphyritic mafic dyke	Archean ?	Cuts mafic volcanics. Porphyries are chloritic.
Pillow Lavas	Archean, 2.677 Ga (Gebert, 1990)	Most abundant rock of Ida Point, rarely variolitic, contain auriferous shear zones.
Mafic volcanics; fine grained gabbro	Archean ?	No mineralization present in these rocks.

Volcaniclasitic sediments	Archean ?	Intensely chloritized, blocks up to 20 cm in diametre. Dominant shear textures present.
Sediment	Archean ?	Small metre size outcrop. Garnet rich zone in the centre of the outcrop.
Tonalite	Unknown, possibly Archean	Small intrusive body, 500 m in diametre. In ductile fault contact with the pillow lavas on the western side. Metamorphic aureole present only on that side. Gold mineralization is present only in the aureole.

3) Igneous Geochemistry

3.1 Analytical methods

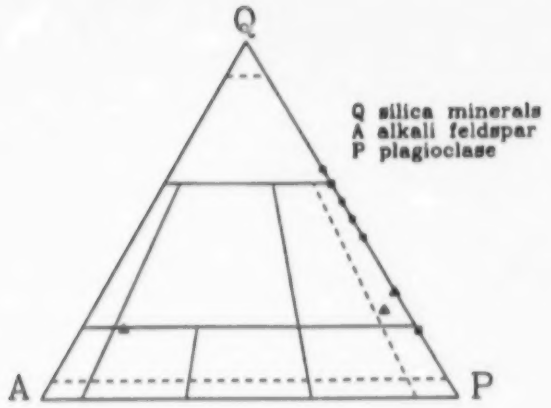
Major, trace and rare-earth elements (REE) analyses were performed on 11 samples from the Ida Point area. Major element analyses were carried out at Chimitec Ltd in Ste-Foy, Québec by plasma-emission. Trace and rare earth elements were determined by instrumental neutron activation analysis (INAA; Gibson and Jagam, 1980) at the Université du Québec à Montréal.

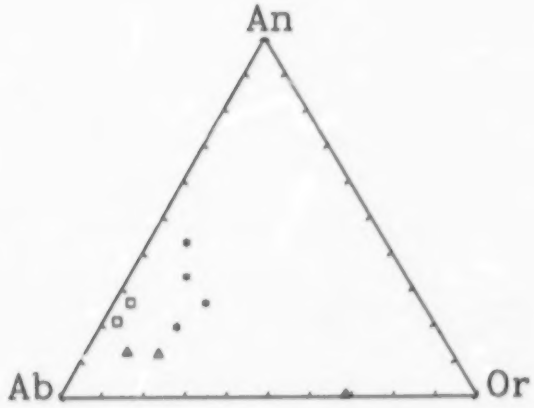
3.2 Major elements

3.2,1 Granitic rocks

Whole-rock analyses carried out on 7 granitic samples including 4 from the Ida Point Intrusion (IPI) and 3 from the Eastern Contact Granitoids (ECG).

Major oxides, trace elements and REE data, are listed in table 2. This also includes CIPW normative values assuming a Fe_2O_3/FeO ratio of 0.15. Major element data are





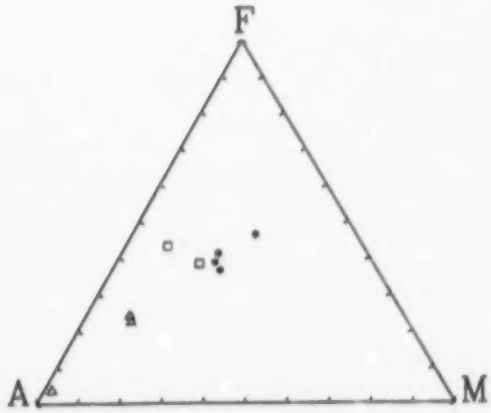


Figure 4: Major element triangular plots

plotted on standard QAP (Streckeisen, 1976), AFM (Wager and Deer, 1939) and An-Or-Ab (Barker, 1979) triangular diagrams (figure 4).

Samples of the Ida Point intrusion (table 1: #5, 6, 8 and 12) are of a tonalitic lithology. Three of the SiO_2 values range from 60.44% to 62.04%. Sample #6 is anomalous with 52.37% SiO_2. All samples plot in the tonalite field on the An-Or-Ab and QAP diagrams (figure 4).

Samples of the ECG (#9, 10 and 11) are more trondhjemitic. SiO_2 values range between 71.95 and 74.63 percent.

All samples are peraluminous ($Al_2O_3 > CaO + Na_2O + K_2O$; ratio > 1.1). However Al_2O_3 is greater than 15 % in the Ida Point intrusive and less than 15% in the Eastern contact granitoid. Harker variation diagrams (figure 5) show that most major oxides have a negative correlation with SiO_2. Sample #11 was taken in the heterogeneous transition zone between granitic rocks and the edge of the greenstone belt. It seems to have sustained considerable potassium alteration as seen in figure 6a (isocon diagram; Grant, 1986). Sample #6 contains more clinopyroxene than any other and thus shows an increase in Ti, Al, Mg, Mn, Ca, Fe.

Both lithologies show a strong calc-alkaline trend on the AFM diagram (figure 4). Major elements of the IPI correspond to the analysis of other tonalites of the Slave Province (Frith and Fryer, 1985), (table 1, figure 5).

3.2,2 Granitic dykes

Two samples (#3, 4) of granitic dykes were taken adjacent to the IPI. Sample #3 contains high silica and low aluminum and is more closely related with the ECG on the Harker diagrams (figure 5). Whereas #4 seems to be more in an intermediate position with a similar composition to the Ida Point intrusion. Field relationships suggest that both dykes are related with the IPI. Their differences lie probably in the higher degree of silicification that #3 has sustained relative to #4. A greater differenciation factor in sample #3 may also explain the different chemistry between the dykes.

Table 2 Analyses of samples from Ida Point
(whole-rock in wt% ; Trace and REE in ppm)

	Lamprophyre		Dyke		IPP				TCG			Tonalites from Slave		
	1	7	3	4	5	6	8	12	9	10	11	A	B	C
SiO2	35.81	32.41	74.61	66.62	62.03	52.37	60.44	62.04	71.95	73.76	74.63	61.60	64.30	62.30
TiO2	0.80	0.87	0.19	0.41	0.53	0.88	0.57	0.55	0.20	0.21	0.03	0.57	0.50	0.72
Al2O3	10.67	10.11	11.17	16.16	15.97	16.70	14.96	15.23	14.71	14.63	13.54	16.20	15.40	16.60
Fe2O3*	10.64	9.06	3.75	4.68	5.10	7.67	5.32	4.98	1.85	2.08	0.35	5.85	4.40	6.57
MnO	0.30	0.22	0.04	0.06	0.07	0.08	0.07	0.07	0.03	0.03				
MgO	16.24	9.40	0.98	2.72	3.46	5.45	3.35	3.93	1.02	0.97	0.16	2.47	2.14	2.56
CaO	7.31	12.92	2.23	3.64	4.82	7.02	5.17	3.63	1.55	1.49	0.25	4.75	3.90	4.23
Na2O	1.94	3.74	4.23	5.19	3.85	3.45	3.71	3.51	4.99	4.52	2.18	4.33	4.79	3.43
K2O	3.16	1.59	0.27	0.43	1.64	0.97	1.40	2.15	0.91	1.63	6.88	1.70	1.89	3.05
P2O5	0.49	0.51	0.17	0.23	0.39	0.51	0.42	0.46	0.11	0.11	0.11	0.13	0.08	0.15
LOI	12.50	18.70	1.70	1.70	2.10	3.30	3.20	2.40	1.60	1.00	0.40	1.14	0.97	1.04
Total	99.85	99.54	99.34	101.84	99.97	98.40	98.61	98.94	98.93	100.43	98.53	98.74	98.37	100.65
Ap	0.94	1.03	0.38	0.51	0.88	1.17	0.94	1.03	0.24	0.24	0.24	0.29	0.18	0.34
Il	1.33	1.52	0.36	0.79	1.04	1.74	1.11	1.07	0.37	0.39	0.06	1.10	0.96	1.40
Mt	3.82	2.81	1.61	1.54	1.48	1.91	1.47	1.34	0.50	0.59	0.10	1.51	0.92	1.47
Or			1.60	2.57	9.98	5.95	8.46	12.92	5.26	9.42	39.75	10.18	11.26	18.34
Ab			35.96	44.42	33.55	30.32	32.10	30.22	41.31	37.41	18.04	37.13	40.87	29.54
An	9.65	5.58	10.00	16.75	22.00	28.27	20.48	15.26	6.82	6.53	0.51	20.01	15.06	20.36
Di	17.09	28.67				3.96	2.62					2.68	3.50	
Hy			1.61	4.51	5.84	8.22	4.92	6.55	1.64	1.55	0.26	3.39	2.61	4.27
Ol	28.80	9.99												
Ne	7.74	15.68												
C			0.55	2.21	0.07			3.32	5.80	5.84	4.53			0.66
Q			43.47	23.88	19.56	8.10	19.69	21.45	34.19	36.13	34.42	17.30	18.90	18.56
Lc	12.67													
Kp	0.06	4.89												
Ns	5.26	5.13	2.10	2.97	3.46	5.47	3.62	3.40	1.20	1.32	0.22	4.01	3.14	4.68
Cs		5.53												
Total	87.36	80.83	97.64	100.14	97.86	95.10	95.41	96.55	97.32	99.43	98.13	97.60	97.40	99.62
A	15.38	21.49	46.65	41.50	37.56	24.03	35.56	37.42	65.73	65.21	94.29	40.20	48.73	39.65
M	48.97	37.91	10.16	20.09	23.67	29.63	23.31	25.98	11.36	10.28	1.67	16.47	15.61	15.67
F	35.65	40.60	43.20	38.41	38.77	46.34	41.14	36.59	22.90	24.51	4.05	43.34	35.67	44.68
Q	46.86	44.45	59.85	55.11	53.91	50.02	54.10	54.77	57.85	58.21	57.44	53.14	53.92	53.16
H	35.85	33.61	4.52	7.32	8.76	15.63	9.97	9.10	2.63	2.80	0.44	9.56	7.91	9.54
L	17.30	21.94	35.63	37.57	37.33	34.35	35.93	36.13	39.51	38.99	42.12	37.30	38.17	37.30
Ce	317.85	328.67	113.77	34.29	97.82	59.75	101.52	96.40	13.78	11.37	2.53	35.60	39.20	54.50
Yb	0.95	0.82	0.20	0.21	0.44	0.38	0.50	0.39	0.11	0.13				
Th	13.86	7.90	19.12	2.76	5.48	1.44	5.19	6.67	3.79	2.34	0.55	0.00	0.00	0.00
Cr	260.80	189.70	7.28	64.05	57.92	94.94	69.96	71.81	2.18	3.38				
Hf	2.19	2.03	3.08	3.31	3.62	1.69	3.57	2.98	3.33	3.62	0.33			
Cs	3.11	0.77	0.82	0.51	0.92	1.06	1.02	1.98	0.35	1.16	1.95			
Sc	17.17	16.43	2.03	9.47	10.62	17.15	10.78	9.63	3.49	2.41	0.63			
Ta	0.58	0.91	0.51	0.25	0.30	0.20	0.30	0.33	0.34	0.32	0.27			
Co	42.03	28.63	18.01	13.38	14.88	27.09	14.49	14.37	4.40	3.33	0.40			
Eu	4.02	3.66	0.48	0.83	1.90	1.63	1.96	1.69	0.48	0.44	0.37	1.40	1.12	1.67
Sm	18.15	16.53	3.96	2.81	7.32	5.29	7.76	6.70	1.15	0.68	0.13	4.20	3.68	6.33
Lu	0.21	0.20	0.10	0.10	0.14	0.11	0.11	0.10	0.04	0.10				
U	3.06	1.83	1.76	0.31	0.87		1.05	0.50	0.71	1.38	0.56	0.00	0.00	0.00
Yb	1.84	1.54	0.63	0.57	0.87	0.75	0.87	0.75	0.34	0.57		1.81	1.11	1.09
La	154.97	158.01	65.30	17.16	46.09	27.37	48.56	46.07	7.31	6.15	1.63	13.10	16.50	22.90

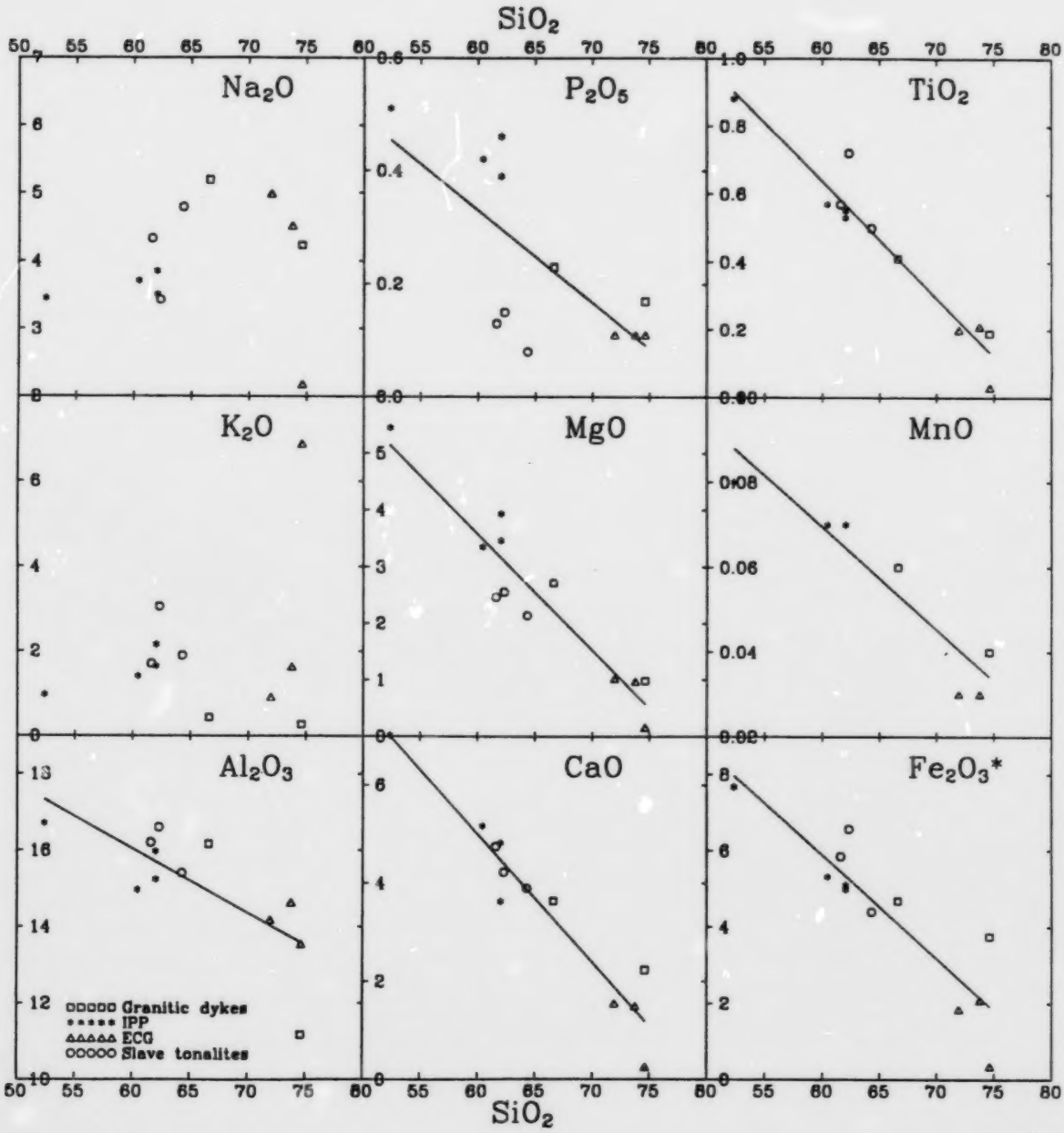


Figure 5: Harker variation diagrams of IPI, ECG and Slave Tonalites.

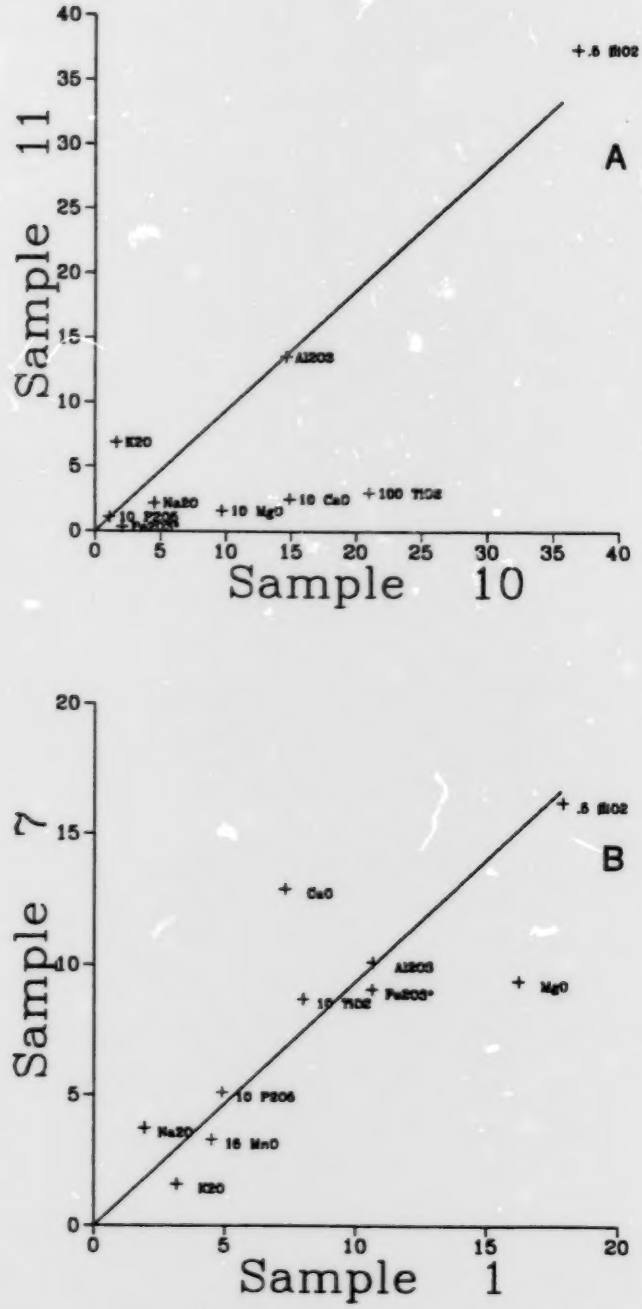


Figure 6: Isocon diagrams of A) ECG samples #10-11 and B) lamprophyre samples #1-7. The x axis represents the unaltered sample.

3.2,3 Lamprophyre

Two samples (#1, 7) of a lamprophyre dyke were analysed. Sample #7 is considered to be an altered equivalent of #1. An isocon diagram (Grant, 1986) (figure 6b) reveals that #7 has sustained substantial increases in CaO and Na_2O (90% in both cases) and a decrease of 37 to 44% in MgO and K_2O respectively. The fresh rock is composed mainly of biotite phenocrysts with a calcite and plagioclase matrix. Magnetite alters to hematite in the fresh sample and recrystalizes in the altered sample. The chemical composition of the lamprophyre (SiO_2 = 35.81%) is close to the average values given for a melilitic lamprophyre, possibly an alnoïte (Strekeisen, 1979).

3.3 Rare earth elements

REE were normalized to the chondrite values of Evenson et al (1978). Granitic rocks are plotted on REE distribution diagrams. Rocks from the Ida Point Intrusion have moderately steep REE patterns and high ΣREE (figure 7). The $[La/Yb]_{(cn)}$ range from 24.6 to 41.4. This is much higher than the ECG's $[La/Yb]_{(cn)}$ ranging from 7.3 to 14.4. Samples from the Eastern Contact Granitoids, however have a more shallow pattern and a higher positive Eu anomaly, 1.8 vs 1.08 for the IPI.

When patterns are compared it is suggested that the ECG could be a cumulate of the IPI. However this is not supported by field evidence. The Ida Point intrusion is only 500m in diametre whereas the ECG is larger than the greenstone belt (figure 2, 3). Furthermore REE patterns and trace elements do confirm that they are definitely two distinct lithologies. Using incompatible elements such as Hf and Ta and comparing their ratio relative to the change in SiO_2, may discriminate the plutons but our data is inconclusive (figure 8).

If the IPI does not derive from the differentiation of the ECG, it is invoked that they are derived form two independent magmatic episodes.

REE patterns of tonalites in the NE Slave province, to the south of Hope Bay (Frith and Fryer, 1985) are similar to the IPI values (figure 8). Differences lie in the steeper slope and the slightly lower positive Eu anomaly of the IPI patterns.

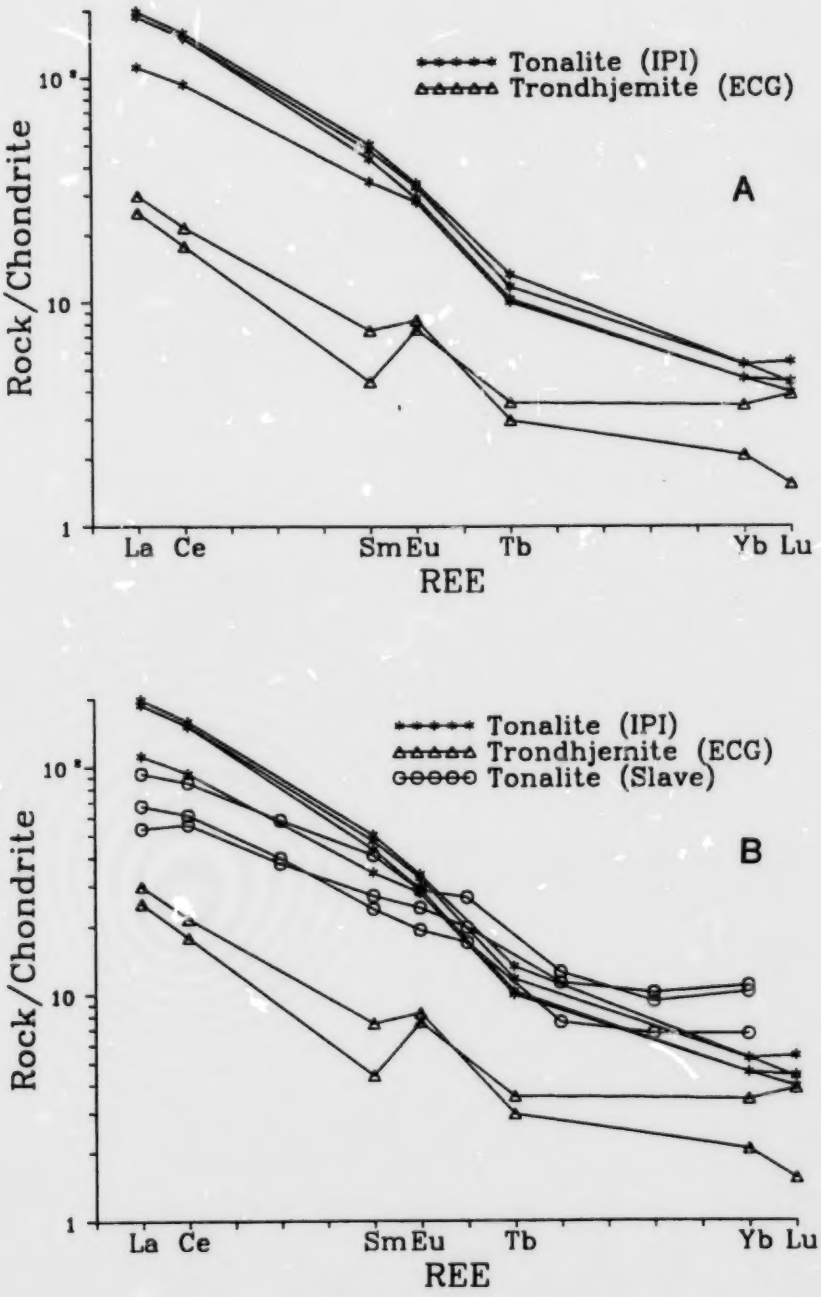


Figure 7: Rare earth element distribution diagrams for the A) IPI, ECG and B) both in comparison with Slave Province Tonalite (Reagan Intrusive Suite).

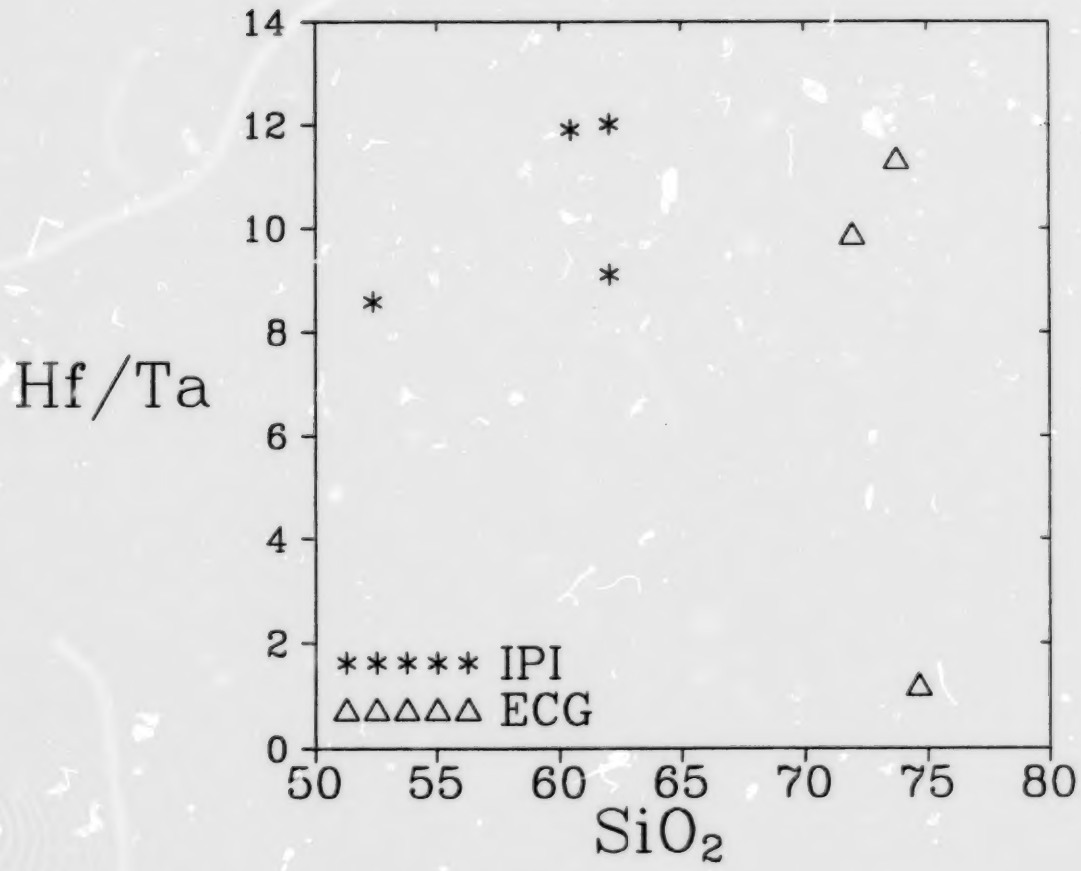


Figure 8: XY diagram representing the correlation between immobile elements Hf/Ta in the granitic rocks. If they would alling then the IPI and ECG would be from the same suite. However, available data is unconclusive.

3.4 Geochronology

An absolute age for the Ida Point Intrusive is not yet available. However, the ECG has been dated at 2.672 +/- 3 Ga (Gebert, 1990, pers. communication). Frith and Fryer published a 2.588 +/- 8 Ga date with the data from the Slave province tonalite (Reagan Intrusive Suite). King, et al., (1990) as also obtained dates on tonalites of the Contwoyto Lake region in the northeastern Slave province. These values range from 2.608 +5/-3 to 2.650 +/-5 Ga.

4) Structure

The rocks are overprinted by three vertical foliations (figure 10). The pillows are elongated with a breath to width ratio of 5:1 along a north-northwestern stretching direction. This may be an indication for the initial shear (figure 9a). Two other shear directions (9b,c), are respectively north-northwest, subparallel to the pillows, and north-east. Vertical lineations measured on shear planes commonly dip to the south. Subhorizontal lineations on these planes indicated lateral mouvement. Shear planes generally dip to the W or NW for all three directions.

The second shear direction (9b), (N-S), contains milky white microsaccharoidal quartz veins where Au mineralization is concentrated in an arsenopyrite rich band found on the borders of the veins. This shear zone is assumed to be pre-intrusion, because it does not cut the tonalite. Sinistral movement is indicated by the rotation of quartz veins.

The third shear direction (9c), (NE) contains smoky and white quartz and visible gold mineralization. A prominent carbonate alteration is present. It overprints the contact metamorphic assemblages. Therefore this type of shear zone is assumed to be post-intrusion. Subhorizontal quartz veins are corrolated with this third shear system. They may represent tension gashes or hydraulic fractures. Structural measurements and relationships show that a vertical ductile mouvement followed by an horizontal dextral movement took place in this third shear system.

A relatively low magnetic anomaly determined with a portable magnetometer is associated with the carbonate alteration due to the disapearence of primary magnetite.

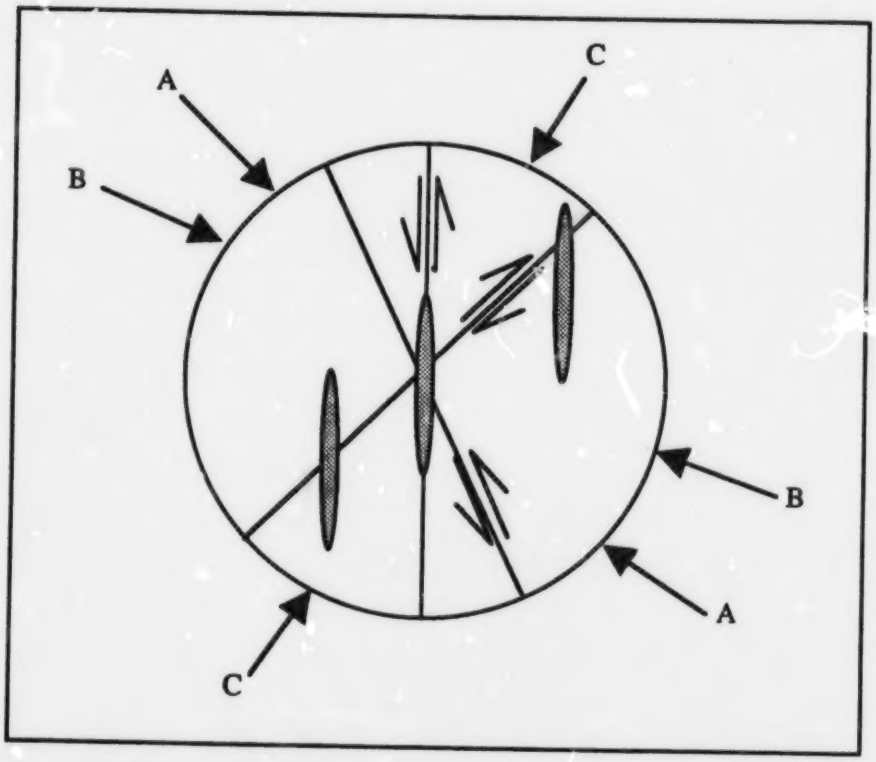


Figure 9: Strain ellipsoïde of deformation sequence in Ida Point. Tension gashes represent sub-horizontal quartz veins associated with third shearing (C).

5) Ore genesis

The shear zone hosted gold mineralization of Ida Point can imply various models of ore genesis (Kerrick, 1989). Three models can be retained in this project.

The Au-rich lamprophyre source rock model by Rock and Groves (1988) require that lamprophyre bodies be temporally and spacially related with mesothermal gold deposits. As lamprophyre magma may originate at or near the core-mantle boundary carrying gold from the core, these could react with the felsic crust, releasing gold into the metamorphic fluid system. Ida Point does contain a lamprophyre dyke, which certainly cuts the mineralization, therefore post dating the ore genesis.

Another model related to the Ida Point setting is the orthomagmatic gold model of Burrows et al., (1986) and Spooner et al., (1987). This model implies a magmatic source for the gold. This assumption is based on evidence from the Mink Lake Mo-Au showing and the associated Tonalite-Trondhjemite body. ^{13}C isotope data for carbonates in the deposits are needed to make the comparison. This type of data is not yet available for Ida Point. Furthermore, the IPI has probably not differentiated enough to concentrate an incompatible element such as Au.

The Metamorphic Dehydration Model (Fyfe and Henley, 1973; Kerrich and Fryer, 1979; Kerrich, 1986, 1987) represents a third option for the ore genesis at Ida Point. This model relates as evidence the spatial association of mesothermal gold deposits with metamophic terranes. It is also apparent that those deposits are associated with major active crustal shear zones correlative with the regional syn-kinematic metamorphism. A "general lack of zoning in associated deposits over large vertical intervals are appropriate for large scale fluide-rock thermal equilibrium , but not with most zoned magmatic systems" (Kerrick, 1989). Metamorphism at Ida Point seems to predate some hydrothermal activity, ie.: the carbonate alteration in the NE trending late shear. The mineralization is also confined to the metamorphic aureole but not associated with large scale un zoned deposits. This may, however, be a convincing model for Ida Point but more isotope data is needed to confirm the model.

A fourth model related with the Metamorphic Dehydration Model but with hydrothermal implications is proposed for Ida Point. Low differentiation in the IPI indicate

that it is less probable that it was the source of the Au mineralization because of the incompatibility of this element. Nevertheless, the fact that mineralizarion occurs only within the metamorphic aureole of the IPI can imply that the intrusion was a factor in the possible remobilisation of the gold from the early to the syn to post intrusion shear zones.

The convection of an aqueous fluid in a porous medium adjacent to an igneous intrusion is modelled by Peacock (1989) (figure 10). This model suggests that heated pore fluids adjacent to the intrusion have a lower density and tend to rise. Cooler higher density fluids replace the rising fluid thus creating a circulation system. This mecanism could be present at Ida Point. Furthermore, using Cathles's (1981) equation, a quantitative mass of fluid put into convection by an intrusion of a given size and temperature can be calculated (Table 3). It is estimated that the IPI can put close to ten times less its own weight of fluid in convection (Q = mass of fluid = 7×10^{13} g). Such a mass would have a high potential for remobilising fluids and metals eventually present in the pillow lava.

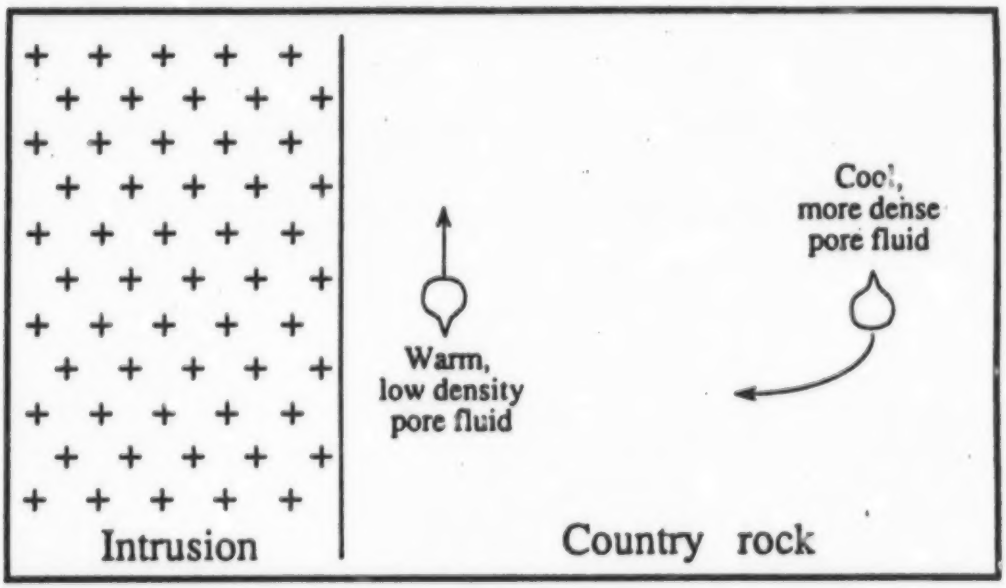


Figure 10: Schematic illustration of convection of an aqueous fluid in a porous medium adjacent to an igneous intrusion (from Peacock, 1989).

Table 3: Cathles (1981) equation for evaluation of the mass of fluid that an intrusion can put in convection.

$$Q/M_i = C_m/C_f \ln \delta T_0/\delta T$$

- Q = Mass of water required to cool an intrusion of a given size to a given fraction of its intrusion temperature (g)
- M_i = Mass of plutonic intrusion (= pmAH)
  - pm= density of rock (g/cm^3)
  - A = surface area of intrusion (cm^2)
  - H = height of intrusion (cm^2)
- C_m = Heat capacity of water-saturated rock formation (cal/g °C)
- C_f = Heat capacity of fluid phase (cal/g °C)
- δT_0 = Temperature contrast of an intrusion relative to ambient at the time of intrusion
- δT = Temperature contrast of an intrusion relative to ambient formation temperature

Data:

- pm = 2.67 g/cm^3
- A = πr
- r = 25000 cm
- A = 2.0E+09 cm^2
- H = 50000 cm
- M_i = 2.6E+14 g
- C_m = 0.2 cal/g °C
- C_f = 1 cal/g °C
- δT_0 = 950 °C
- δT = 250 °C

Results:

$$Q = 7.0E+13 \text{ g}$$

6) Conclusion

In this preliminary investigation of the relation of the IPI and the gold mineralization on Ida Point, it is established that two sodic plutonic bodies occur near Ida Point: the IPI (tonalite) and the ECG (trondhjemite). REE data indicates that they are two distinct magma represent two magmatic episodes.

Although the IPI is faults bounded on each side, mineralization is only present on its western side. This may be due to the lack of shear structures on the east side or possibly to the western dip angle of the intrusion.

Several metallogenic models can be tested at Ida Point. The metamorphic dehydration model constitutes a close approximation, however more isotopic data is needed to confirm it. Furthermore, the incompatibility of Au makes it difficult for the IPI to be the source of the mineralization. However the heat from such a magma may have influenced the remobilisation of the gold already present in the adjacent pillow lavas. In fact a tonalite of that size and typical heat can generate 10 time less its weight of water in convection.

Further work should include isotopic data of the carbonates in the mineralized zone. Fluid inclusion studies must be done to establish a good control on the hydrothermal fluid type that was probably involved in the mineralization. As a more general approch, other Au mineralization zones must be studied in order to relate them to the mineralization on Ida Point.

The Ida Point gold showing can contribute some prospecting guides for the HBGB. These can include the search for late tonalitic intrusion. Whether or not a contact metamorphic aureole is present. Finally, the presents of several crosscutting shear systems in the contact aureole is essential as a host for the mineralization.

References

Barker, F., 1979. Trondhjemites: definition environment and hypothesis of origin. In: Barker F. (eds.) Trondhjemites, dacites and related rocks, Amsterdam, Elseveir, 1-12.

Boyle, R.W., 1979. The Geology and geochemistry of gold deposits of the Yellowknife district; Geological Survey of Canada, Memoir 310, 193 p.

Burrows, D.R. and Spooner, E.T.C., 1986. The McIntyre Cu-Au deposit, Timmins, Ontario, Canada. In: MacDonald A.J. (eds.) Gold'86 Consult International, Toronto, p.23-39

Colvine, A.C., Fyon, J.A., Heather, K.B., Marmont, S., Smith, P.M., and Troop, D.G., 1988. Archean lode gold deposits in Ontario; Ontario Geological Survey, Miscallaneous Paper 139, 139 p.

Evenson, N.M., Hamilton, P.J. and O'nions, R.K., 1978. Rare earth abundances in chondritic meteorites. Geochimica Cosmochimica Acta, v. 42, pp. 1199-1212

Frith, R.A and Fryer, B.J., 1985. Geochemistry and origin of the Regan Intrusive Suite and other granitoids in the northeastern Slave Province, northwest Canadian Sheild. Can. J. Earth Sci., v. 22, pp. 1048-1065

Fyfe, W.S. and Henley, R.W., 1973. Some thoughts on chemical transport processes with particular reference to gold. Minerals Science Engineering, v. 5, pp. 295-303

Gebert, J., 1989. Preliminary Geology of Southern Hope By Metavolcanic Belt; EGS 1989-8, Map with marginal notes.

Gebert, J., 1990. The geology fo the Hope Bay and Elu Inlet metavolcanic belts, Northeastern Slave Province, N.W.T. In: Canada Northwest Territories Mineral Development Aggrement. GNWT-DIAND Geoscience projects 1989 Annual report.

Gibson, I.L. and Jagam, P., 1980. Intrumental neutron activation analysis of rocks and minerals. In: G.K. Muecke, Short course in neutron activation analysis in the geosciences. Mineralogical Association of Canada, short course handbook, v. 5, pp, 109-131

Grant, J.A., 1986. The Isocon diagram - A simple solution to Gresens' Equation for metasomatic alteration. Economic Geology, v. 81, pp. 1976-1982

Ishihara, S., 1981. The granitoid series and mineralization. Economic geology, 75th Anniversary Volume, pp. 458-484

Kerrich, R. and Fryer, B.J., 1979. Archean precious-metal hydrothermal systems, Dome Mine, Abitibi Greenstone Belt: Part II. REE and oxygen isotope relations. Can. J. Earth Sci., v. 16, pp. 440-458

Kerrich, R., 1986. Fluid infiltration into fault zones: chemical, isotopic and mechanical effects. Journal of Pure and Applied Geophysics, v. 124, pp. 225-268

Kerrich, R., 1987. The stable isotope geochemistry of Au-Ag vein deposits in metamorphic rocks. In: Kyser, T.K. (eds.) Stable isotope geochemistry of low-temperature fluids. Mineralogical Association of Canada, Short course 13, pp. 287-336

Kerrick, R., 1989. Shear zone hosted mesothermal gold deposits; a review of geochemical evidence on the sources of fluids and solutes. In: Burnsnall, J.T. (eds.) Mineralisation and Shear Zones: Geological Association of Canada Short course notes, v. 6, chap. 4, pp. 89-128

King, J.E., Davis, W.J., Relf, C. and T. Van Nostrand, 1990. Geology of the Contwoyto - Nose Lakes map area, central Slave Province, District of Mackenzie, N.W.T. in press.

Peacock, S.M., 1989. Thermal modelling of metamorphic pressure-temperature-time paths: A forward approach. In: Metamorphic Pressure temperature Time Path. American Geophysical Union Short course in Geology, v. 7, pp. 57-102

Rock, N.M.S. and Groves, D.J., 1988. Can lamprophyre resolve the genetic controversy over mesothermal gold deposits?. Geology, v. 16, pp. 538-541

Spooner. E.T.C., Bray, C.J., Wood, P.C., Burrows, D.R. and Callan, N.J., 1987. Au-quartz vein and Cu-Au-Ag-Mo-anhydrite mineralization, Hollinger-McIntyre Mines, Timmins, Ontario: $\delta^{13}C$ values (McIntyre) fluid inclusion gas chemistry, pressure (depth) estimation, and H_2O-CO_2 phase separation as a precipitation and dilation mechanism. Ontario Geological Survey, Miscellaneous Paper, v. 136, pp. 35-56

Streckeisen, A., 1976. To each plutonic rock its proper name. Earth Sci. Rev., v. 12, pp. 1-33

Streckeisen, A., 1979. Classification and nomencalture of volcanic rocks, lamprophyres, carbonatites, and melilitic rocks: Recommandation and suggestions of the IUGS Subcommission of the Systematics of Igneous Rocks. Geology, v. 7, pp. 331-335

Wager, L.R. and Deer, W.A., 1939. The petrology of the Skaergaard intrusion, Kangerdlugssuag, East Greenland. Meddeleiser om Grønlan, v. 105, n. 4, pp. 1-352